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ABSTRACT

This paper describes a management system for secondary vocational education programs that is based on a cost-effectiveness analysis model. The model described was developed specifically for use in planning and evaluating secondary school vocational programs, although it might be applied to other educational programs as well. The model generates cost-effectiveness measures to determine the degree of effectiveness, efficiency, and management performance of vocational programs. The authors suggest that a standard procedure for using the model, together with user-oriented data forms, will assist vocational administrators and educators in conducting cost-effectiveness analyses and in improving their management skills. (Author/JG)

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A MANAGEMENT SYSTEM

BASED ON A COST-EFFECTIVENESS MODEL

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A MANAGEMENT SYSTEM

BASED ON A COST-EFFECTIVENESS MODEL

by

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The management of secondary vocational education programs has been of interest to a number of systems people. Much of this interest appears to stem from federal or state mandates for planning and accountability. However, evaluation and research specialists have also produced information systems of considerable importance. The project discussed in this paper applies an economic based evaluation system, cost-effectiveness, to the management of vocational education programs.

The purpose of the project was to develop a system by which local program administrators could base their operational and planning decisions on a rational basis: a relationship of program outcomes to cost. The system is locally operationalized and sufficiently refined to permit local agency personnel to conduct all phases of the process indepen nt of a third party evaluator or consultant. Second, the system coordinates planning techniques with cost analysis evaluative techniques.

Description of Cost-Effectiveness Analysis

While the actual processes for conducting a cost effectiveness investigation are rigorous and highly complex, the basic relationship can be

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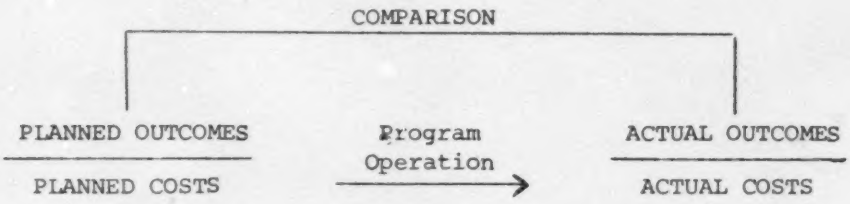
expressed quite simply. Essentially, the C/E ratio is a comparison of alternative courses of action in terms of their costs and their effectiveness in attaining some specific objectives as follows:

$$\text{COST-EFFECTIVENESS} = \frac{\text{OUTCOMES}}{\text{COST}}$$

Objectives expressed as a numerical value become the numerator in this ratio. Expenditures or costs are the denominator. The resulting values become meaningful only in relationship to other similarly derived ratios but where the inputs vary.

Typically, cost-effectiveness analyses have considered programming considerations like cooperative education vs. traditional school based programs (Stromsdorfer, 1972) and public post-secondary occupational program vs. proprietary programs (Wilm, 1974). Applications of cost effectiveness in this project differ fundamentally from the typical comparisons. The system developed in this project is positive in nature. It is a comparison of a program against itself during two points in time. The same ratio is applied but the inputs into the ratio differ by point in time. Specifically, these inputs are planned outcome/costs and actual outcome/costs.



The result of the analysis has been termed a performance ratio. This index is a numerical statement of a given program's planned cost-outcome ratio

with its actual cost-outcome ratio with program operation serving as quasi-treatment, which is expressed as follows:

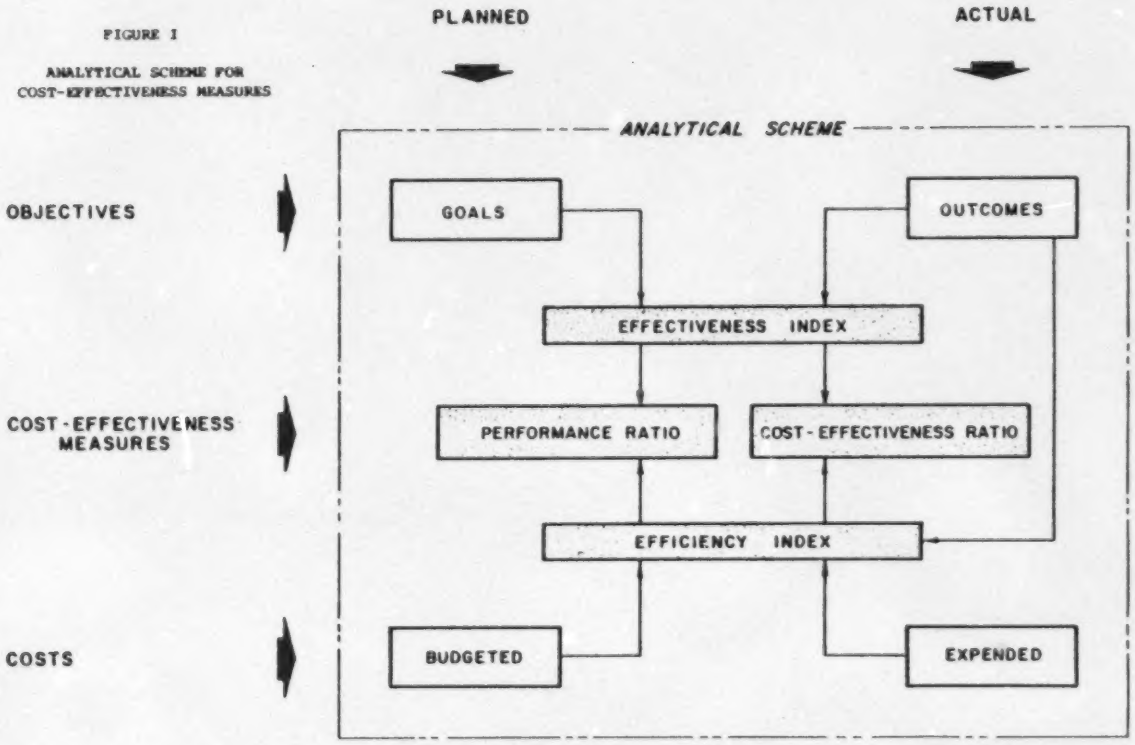
$$\text{PERFORMANCE RATIO} = \frac{\frac{\text{ACTUAL OUTCOMES}}{\text{ACTUAL COSTS}}}{\frac{\text{PLANNED OUTCOMES}}{\text{PLANNED COSTS}}}$$

The performance ratio is an estimate of the effectiveness and efficiency of the program's management and operations. It provides essential feedback for planning subsequent programs of the same type. For example, adjustments can be made in support for the program or, anticipated outcomes can be adjusted.

Classically applied terms relating to management assume traditional definitions and are meaningfully related (See Figure 1). Effectiveness relates to the product: "How effective was the program in producing the expected product?" Efficiency pertains to cost: "How efficient was the program in its operation?" By contrasting effectiveness and efficiency while controlling for the units of output, a cost-effectiveness ratio is provided. The management model incorporates these four indices of performance. Figure I shows a pictorial display of the relationship of variables to indices.

FIGURE I

ANALYTICAL SCHEME FOR
COST-EFFECTIVENESS MEASURES



Four Kinds of Cost-Effectiveness Measures

Four numerical measures can be generated from the relationship among program objectives, outputs, and costs.

Program Effectiveness. First, effectiveness is defined as "a measure of the achievement of program objectives" (Forbes, 1974, p. 21). Accordingly, program effectiveness is measured by the degree of target goal attainment, the extent to which the goal is achieved.

Program Effectiveness (PE_i) scores are computed by dividing the actual outputs (O_i) by the expected target goals (G_i), or

$$PE_i = \frac{O_i}{G_i} \quad \ldots\ldots\ldots\ldots\ldots (1)$$

For instance, if 100 percent of the enrollees were expected to complete a program, but 90 percent actually completed the program, effectiveness score of the program indicates a 90 percent.

Furthermore, a number of effectiveness scores can be combined into a program effectiveness index. A Composite Program Effectiveness (CPE) index is made by adding all available effectiveness scores. Dividing the composite index by a number of effectiveness scores (N) provides an Average Program Effectiveness (APE) index. They are expressed by:

$$CPE_i = \sum_{i=1}^{n} \frac{O_i}{G_i} \quad \ldots\ldots\ldots\ldots (2)$$

$$APE = \frac{\sum_{i=1}^{n} \frac{O_i}{G_i}}{N} \quad \ldots\ldots\ldots\ldots (3)$$

If each program effectiveness is weighted on the basis of policy preferency or importance of program objectives, then a Weighted Composite Program Effectiveness (WCPE), and a Weighted Average Program Effectiveness (WAPE) index can be made as follows:

$$WCPE = \sum_{i=1}^{n} \frac{O_i}{G_i} \cdot W_i \quad \ldots\ldots\ldots\ldots (4)$$

$$WAPE = \frac{\sum_{i=1}^{n} \frac{O_i}{G_i} \cdot W_i}{\sum_{i=1}^{n} W_i} \quad \ldots\ldots\ldots\ldots (5)$$

Cost Efficiency. Second, efficiency is measured by the cost and output relationships which result in unit costs. The proposed model attempts to compute unit costs as efficiency measures by dividing total costs of the program by units of the outputs, such as total number of program completions or graduates. Thus, Actual Cost Efficiency ($CE_{(a)}$) measures can be made by dividing Actual Total Cost of the program ($C_{(a)}$) by units of outputs, such as total number of completions (O_1), students enrolled in the program, (O_2), or student contact hours (O_3). Each of the products is called Actual Unit Cost ($UC_{(a)}$) which is expressed by:

$$CE_{(a)} = \frac{C_{(a)}}{O_1}, \frac{C_{(a)}}{O_2}, \frac{C_{(a)}}{O_3}, \text{ or } UC_{(ac)} \quad \ldots\ldots\ldots (6)$$

By analyzing budget costs for the vocational program, Budgeted Cost Efficiency ($CE_{(b)}$) measures are made in the same way as Formula 6, above. They are expressed by:

$$CE_{(b)} = \frac{C_{(b)}}{O_1}, \frac{C_{(b)}}{O_2}, \frac{C_{(b)}}{O_3}, \text{ or } UC_{(b)} \quad \ldots\ldots\ldots (7)$$

Furthermore, a Cost Efficiency Index (CEI) can be derived from the computation of actual total or unit cost over budgeted total or unit cost for the vocational instructional program. If an average of standardized unit cost information would be available, the actual unit cost would be compared with average or standardized cost to produce a cost efficiency index. By comparing (6) with (7), a Cost Efficiency Index (CEI) is made as follows:

$$CEI = \frac{C_{(a)}/O_1}{C_{(b)}/O_1}, \frac{C_{(a)}/O_2}{C_{(b)}/O_2}, \frac{C_{(a)}/O_3}{C_{(b)}/O_3}, \text{ or } \frac{UC_{(a)}}{UC_{(b)}}$$

$$= \frac{C_{(a)}}{C_{(b)}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

Cost-Effectiveness Ratio and Performance Ratio. Finally, based upon the measures of program effectiveness and cost efficiency, a cost-effectiveness ratio and a performance ratio can be computed. A Cost-Effectiveness Ratio (C/ER) is derived by:

$$C/ER = \frac{(2), (3), (4), \text{ or } (5)}{(6)} \quad \ldots\ldots\ldots\ldots (9)$$

The ratio indicates the degree of goal attainments per unit cost. This computation of a cost-effectiveness ratio would be somewhat different from a commonly used method which is dividing outputs by the total or unit cost as inputs (Knezevich, 1973, p. 204; Handbook II, 1973, p. 70).

A Performance Ratio (PR) is generated from the division of program effectiveness by cost efficiency index as follows:

$$PR = \frac{(2), (3), (4), \text{ or } (5)}{(8)} \quad \ldots\ldots\ldots\ldots (10)$$

This performance ratio indicates more or less than one unit using average program effectiveness indices. Also, it is a precise index representing the relationship between the program effectiveness and cost efficiency as measured by formulas one through nine. Therefore, the ratio should be interpreted along with both effectiveness and efficiency implications in evaluating the vocational instructional program.

A Cost-Effectiveness Analysis Model

In analyzing cost-effectiveness of secondary vocational programs, a conceptual model was developed to include: (1) classifying vocational programs, (2) specifying measurable program objectives, (3) assessing program outputs, and (4) determining program costs.

Classifying Vocational Programs. For a cost-effectiveness analysis of secondary vocational programs, the vocational program is distinguished from its academic counterpart at the senior high school level. The U.S. Office of Education developed an educational program classification (1969) in which there are seven vocational-technical areas. Each of the vocational education program areas is divided into sub-programs or courses, such as "agricultural mechanics," in the agriculture program area. The vocational sub-program areas or courses can be defined as instructional programs to be basic units of analysis. One instructional program or all programs offered at a school can be selected for

a cost-effectiveness analysis. Also this analytical technique can be used for comparing the cost-effectiveness of similar programs between schools.

Specifying Program Objectives. Program objectives can be described by the operating thrusts of local vocational administrators in product-oriented terms by defining the outcomes anticipated from the local vocational programs. Furthermore, the program objectives should be specified in measurable goals which define degrees of attainment within the vocational instructional program.

Using these criteria, a set of program objectives was developed as follows:

1. Aid students enrolled in vocational education to successfully complete a secondary occupational program.
2. Assist special student groups to successfully complete a secondary vocational program.
3. Provide vocational education for secondary school youth in accordance with their occupational preparation.
4. Provide leadership development activities for students enrolled in vocational programs through a youth organization functioning as an integral part of the vocational instruction.
5. Provide guidance and counseling services (career development) information appropriate to continued education or employment for students enrolled in vocational programs.
6. Provide vocational programs to fulfill the requirements of the labor markets and the employment community's manpower needs.
7. Encourage vocational graduates to continue their education after completion of their secondary program.

Each of these program objectives should be described in measurable terms as to degree of its attainment. For example, objective one would include a number of target goals indicating how many (or what percentage) of students enrolled in the vocational instructional program will complete the program and the degree of satisfaction with the program, as illustrated in the following:

1. Aid students enrolled in vocational education to successfully complete a secondary occupational program.

1-a. _____ students will complete the vocational program during the school year.

1-b. _____ percent of the students will complete the program requirements.

1-c. _____ percent of student completions will have on-the-job occupational experience.

1-d. _____ percent of the students will not dropout of the vocational program during the school year.

1-e. _____ percent of student completions will rate their program as satisfactorily meeting their goals.

In the same way the other objectives can be stated in measurable target goals which define degrees of attainment within each program objective.

Assessing the Program Outputs. Program outputs are the products or expected results from the program. They are often expressed by indicating the results or impacts of school education. Program outputs are defined, however, by attainment of predetermined objectives as desired outcomes resulted from vocational instructional programs. Accordingly, the scope and contents of the program outputs are determined by a set of program objectives.

Determining Program Costs. Program costs are defined as annual expenditures for operating the vocational instructional program at the local school district level. This definition excludes foregone income and the time of students while they are in the program. Also expenditures are to be analyzed on one-year basis without consideration of the present value of a multi-year cost.

According to the Handbook II, recommended by the U.S. Office of Education (1973), program costs may be analyzed by direct and indirect

costs. Direct costs can be defined as expenditures directly related to the instructional program. The following six items would be included as direct costs of the instructional program.

1. Annual salaries of teaching staff within the instructional program.
2. Fringe benefits for teaching staff within the instructional program.
3. Travel costs for instruction related to the program.
4. Costs of instructional supplies and materials assigned to the instructional program.
5. Costs of classroom and laboratory facilities and equipment used by the instructional program.
6. Building use costs assigned to the instructional program.

A sum of all costs of the six items accounts for the instructional direct costs. When evaluating one program within a school or comparing two or more programs in the same school, building use cost may be excluded from the direct cost of the instructional program.

After the direct costs have been totalled, indirect costs must be figured. The following supporting services indirect costs can be prorated to the instructional program:

1. Student support service costs.
2. Instructional staff services costs.
3. General administration services costs.
4. School administration services costs.
5. Business services costs.
6. Central support services costs.

The prorated costs of all supporting services are added to the supporting indirect cost of the instructional program. The sum of direct and indirect

costs represents a total cost of the vocational instructional program. Based upon the annual budget, total costs of vocational programs can be figured by repeating the same procedures as mentioned above. These costs may be called budgeted total costs of vocational programs.

An Illustration of Cost-Effectiveness Measures. Following the formulas and information mentioned above, the four kinds of cost-effectiveness measures are illustrated using hypothetical data on program objectives, outputs and costs.

Suppose three vocational instructional programs (A, B, and C) were selected from among the vocational programs within an area vocational school for analysis. At the beginning of the school year, program objectives were specified by three target goals of each program: (1) number of expected completions, (2) percentage of passing licensure examinations, and (3) percentage of expected employment. After program operation, program outputs were identified by actual attainments as associated with each of the target goals. And also program costs were analyzed to identify both actual and budgeted costs for each instructional program. Finally, hypothetical data were given to each program as shown in Table I. (See Table I).

Based on the data, cost-effectiveness measures were computed, using the formulas one through ten as developed in this paper. The computing procedures were as follows (See Table II):

1. Program effectiveness scores were computed by dividing outputs by target goals, using Formula one. Then each score was weighted according to its importance: 15 points for employment, 10 points for test-pass, and 5 points for completion.

2. Composite and average program effectiveness indices were made by adding the effectiveness scores, following Formulas two and three. Based on the weighted effectiveness scores, weighted composite and weighted average effectiveness indices were made, using Formulas four and five.

3. Cost efficiency was measured by unit costs. Actual and budgeted unit costs per completion were computed by Formulas six and seven.

4. A cost efficiency index was made by dividing actual unit or total cost by budgeted unit or total cost, using Formula eight.

5. Finally, according to Formula nine, a cost-effectiveness ratio was computed by dividing the weighted average effectiveness index (2-d) by the actual unit cost (3-a). Then a performance ratio was derived from the division of the weighted average effectiveness index (2-d) over cost efficiency index (4), using Formula ten.

As a result, cost-effectiveness measures for each instructional program could be figured out as they appear in Table II. Program effectiveness index, cost efficiency index, and cost-effectiveness ratio or performance ratio provide a basis for answering three questions: (1) Which program is relatively most effective? (2) Which program is relatively most efficient? (3) Finally, which program performs in the most effective and efficient ways?

TABLE I

HYPOTHETICAL DATA FOR A COST-EFFECTIVENESS ANALYSIS

Data Classification	Instructional Programs A	B	C
1. Objectives: Targeted Goals			
a. # Expected completion	50	40	45
b. % Passing tests	90%	80%	75%
c. % Expected employment	80%	70%	60%
2. Outputs: Actual Attainments			
a. # Actual completions	45	35	40
b. % Passed	85%	75%	60%
c. % Actual employed	70%	60%	50%
3. Costs: Budgeted/and Expended			
a. $ Total annual expenditure	$55,000	$35,000	$38,000
b. $ Total annual budget	$50,000	$35,000	$40,000

TABLE II

COMPUTATION OF COST-EFFECTIVENESS MEASURES,
USING HYPOTHETICAL DATA

C/E Measures	Instructional Programs A	B	C
1. Program Effectiveness Scores			
a. % Completion	90.0%	87.5%	88.9%
b. % Test-pass	94.4%	93.8%	80.0%
c. % Employment	87.5%	85.7%	83.3%
(Weighted Effectiveness Scores)			
d. % Completion X 5	450.0	437.5	444.5
e. % Test-pass X 10	944.0	938.0	800.0
f. % Employment X 15	1312.5	1285.5	1249.5
2. Program Effectiveness Index			
a. Composite index: (1a + 1b + 1c)	271.9	267.0	252.2
b. Average index (2a)/3	90.6	89.0	84.1
c. Weighted composite index: (1d + 1e + 1f)	2706.5	2661.0	2494.0
d. Weighted average index: (2c)/30	90.2	88.7	83.1
3. Cost Efficiency: Unit costs			
a. Actual unit cost per completion	$ 1,222	$ 1,000	$ 950
b. Budgeted unit cost per completion	$ 1,111	$ 1,000	$ 1,000
4. Cost Efficiency Index			
a. Actual unit cost/budget unit cost, or	1.1	1	.95
b. Actual total cost/total budgeted cost	1.1	1	.95
5. C/E ratio and performance ratio			
a. C/E ratio: (2d)/(3a)	.074	.089	.087
b. Performance ratio: (2d)/(4a)	82.0	88.0	87.4

Referring to program effectiveness index, Program A can be judged most effective among the three programs, whereas Program C can be considered most efficient on the basis of cost efficiency index. Furthermore, according to performance ratio, Program B would be judged most effective and efficient among the three programs. Thus, these cost-effectiveness measures can be utilized as criteria in evaluating or comparing the degree of effectiveness, efficiency, and performance of vocational instructional programs.

State-of-the-Art Considerations

Because of the uniqueness of the system, it is well to point out what the system is not. First, comparisons with other programs may be meaningful to obtain understanding of relativeness of the system, but practically, the system should not be applied to comparisons of programs. Such comparisons would lead to offering only the cheapest high density programs. Second, comparisons between districts are tantalizing but the lack of control on the range of variables would make these comparisons dangerous folly.

The project has completed the initial conceptualization and developmental phases resulting in two products: a technical report which (1) develops the theoretical basis for this model, (2) explains the model in detail, (3) discusses the data systems, and (4) notes the formative evaluation process (Kim and Harris, 1976). The second product is an administrator's manual which is an operation handbook for conducting the system (Kim, Harris, and Ruby, 1976). Several features of the manual should be noted. The manual is self instructional and is structured around a series of increasingly more specific questions about the system. Procedures are PERTed and instructions are sequentially noted, all tasks specified in the instructions are indexed with appropriate forms.

Forms for obtaining and summarizing all data are provided. Forms include both outcome statements, follow-up instruments, cost analysis tables, program tables and analytical tables.

A grant for a diffusing phase has been obtained. The purpose of this current activity is twofold: (1) to provide limited controlled adoption where training methods can be refined and (2) to provide a field study conducted by the target actors. These activities will lend support to work on writing interpretation guidelines.

Summary

The cost-effectiveness model and system developed in the project has the potential for improving the decision making process concerning the development and operation of vocational education programs. While future research may well improve the model and system, this initial effort provides administrators with a manageable investigative technique.

The project has been successful in developing a system for conducting secondary school level cost-effectiveness investigation materials. The system provides information for decision makers relative to evaluation, program planning, and utilization of resources. Two documents have been developed for state and national dissemination. These documents, a technical report designed for researchers and an administrator's manual designed for conductors of the investigations, provide a thorough outline of the model and steps to be taken in conducting investigations.

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